# Space Weather Technical Forecast

Issued on Saturday, 29 July 2023 at 01:28 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: Ongoing daily risk of R1/R2 radio blackouts. Risk of S1/Minor Proton storms on 29 Jul.**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity has been Moderate, with one M-class, a M4.1 at 28/1558 UTC, likely from ex-AR3376 which is now 24 hours beyond the northwestern horizon. This flare was accompanied by a large farsided halo CME, which has been assessed as not being Earth directed. On the visible disc, AR3380 has developed a circle of smaller spots, which have increased the magnetic complexity of the region. A CME was emitted from the vicinity of this region around 28/0200UTC, but analysis suggests that any CME is unlikely to affect the Earth. AR3386 is also developing and carries a high risk of M-class flaring. Remaining regions appear simple or stable, but a number of regions are emerging across the eastern limb, with a full classification not yet possible.

Three filament eruptions appear to be underway, the most notable, a large filament in the northeast, along with two smaller ones in the south-central and southwestern regions of the Sun. These will be assessed as data becomes available.

**Solar Wind / Geomagnetic Activity:** The solar wind, as measured at L1, appears to be in an ambient region with solar wind speeds gradually falling below 400km/s following a possible very weak coronal hole high speed stream connection. Density has steadily fallen to below average values. Total magnetic field strength has been weak and steady throughout. The north-south component, Bz, has varied weakly between positive and negative polarities, with a recent sustained but weak period from 28/1600 UTC. Phi angle was predominantly positive (away from the Sun). Total geomagnetic activity was Quiet with one Unsettled interval at the end of the forecast period.

**Energetic Particles / Solar Radiation:** GOES16 high energy (greater than 10MeV) proton flux has been steadily rising towards the S1/Minor Storm threshold. This is the result of a large farsided proton rich M-class flare from ex-AR3376, which was accompanied by a full farsided halo CME. The rate has slowed in the last four hours but is still approaching the threshold.

GOES16 high energy (greater than 2MeV) electron flux ranged between moderate and background levels. 24-hour integrated fluence was 2.73e7 integrated pfu at 29/2100UTC.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** There is a chance of M-class flaring throughout the period, with an increased risk of 29 Jul due to the risk of further flaring from an active region beyond the northwestern limb. A number of regions on the eastern limb are likely to be re-classified as more complex regions in the forthcoming days with consequent increase in risk of M-class flares.

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**Solar Wind / Geomagnetic Activity:** Two CMEs, from the south central disc and from just beyond the northwestern limb were analysed, with neither showing an Earth-directed component. Three further filament eruptions, most notably from a large filament in the northeast are in progress and will be assessed as imagery becomes available, but may affect the forecast towards the end of the period. Otherwise no coronal hole high speed streams are forecast to connect with Earth, with mainly ambient speeds expected. Quiet geomagnetic activity is currently expected throughout, considering the above caveats.

**Energetic Particles / Solar Radiation:** There is a chance of the high energy (greater than 10MeV) proton flux reaching the S1/Minor Storm level on 29 Jul in the absence of further eruptions from ex-AR3376. The risk is then expected to decline through the period as ex-AR3376 moves further onto the far side and the current proton levels subsiding.

The high energy (greater than 2MeV) electron flux is forecast to remain below the high (1e3 pfu) threshold, with the associated fluence is forecast to remain below the Active (1e8 integrated pfu) threshold during this period.

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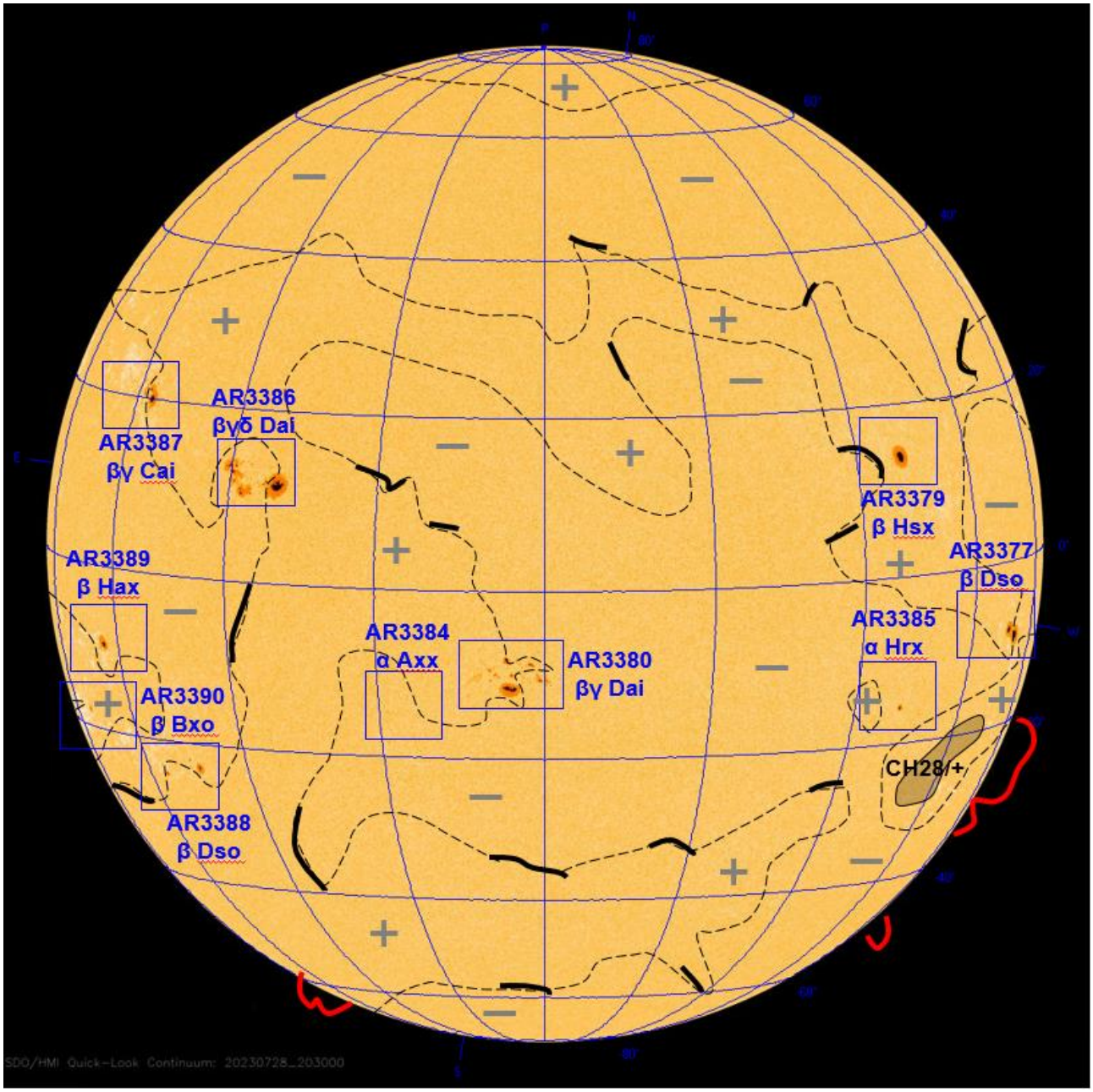
**Figure 1. Solar Analysis Valid 28/2000 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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**Geomagnetic Storms:**
A large farsided CME on 28 Jul has been modelled and assess have having no Earth influence. A further CME from the southwest of the Sun around 28/0200 UTC appears to also be missing the Earth. There are also three eruptions in progress, which may have an impact on future geomagnetic forecasts. The large filament in the northeast appears to be in the process of lifting off and may present a risk of a glancing blow at Earth. Two further eruptions, once close to AR3380 and one close to AR3385 visible on SDO/AIA 211 around 28/2200 UTC may present a more Earth-directed component. These will continue to be monitored.

Solar winds are currently at background, with the forecast connection to the high speed stream from coronal hole 28 not discernible on L1 data. This is a weak feature and is now considered to be unlikely to connect. No further high speed streams are forecast to connect within the next four days.

Geomagnetic activity is expected to be Quiet with isolated Unsettled spells. The risk of Earth-directed CMEs later in the period, possibly 31 July and 01 August will be assessed once the filaments have lifted off and sufficient imagery becomes available.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 1 | 1 | 1 | 1 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

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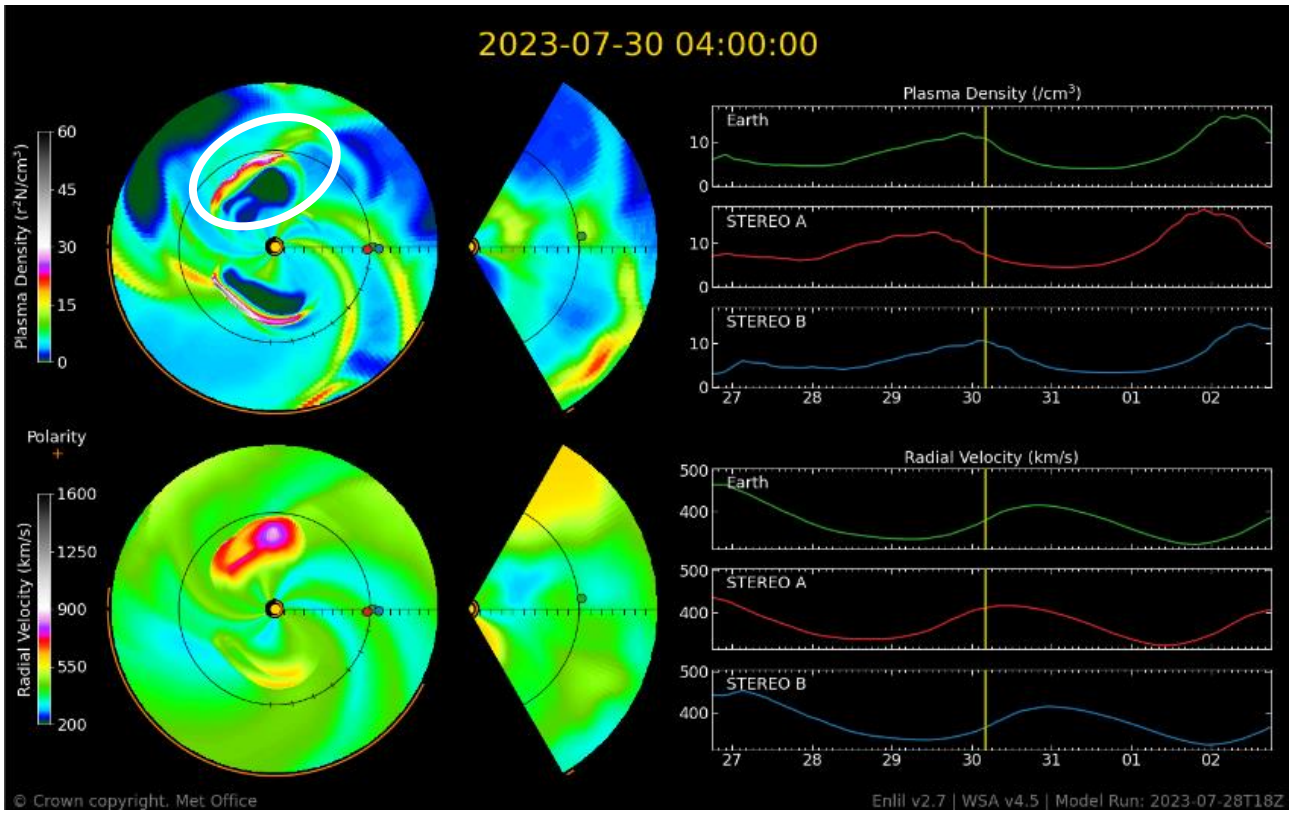
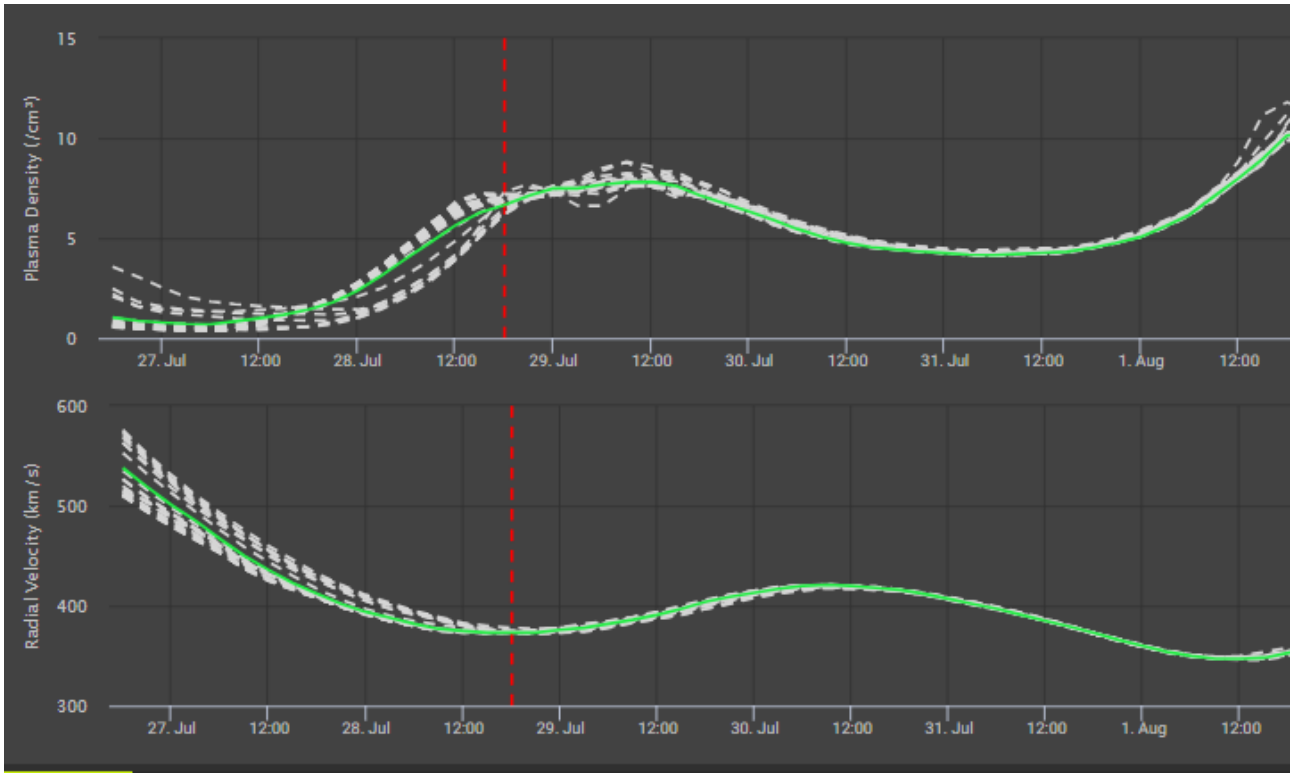
**Figure 2: Enlil MOSWOC and Enlil MOSWOC ensemble forecast, showing that the large farsided CME is likely to arrive at Earth during the forecast period.**

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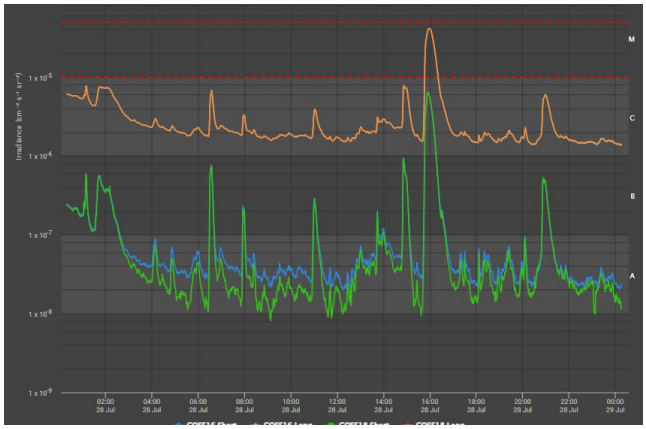
**Radio Blackouts - X-Ray Flares:**
Solar activity has been Moderate, with one M-class flare from a region, possibly ex-AR3376, just beyond the northwest limb. This produced a large farsided CME and an elevated proton response. Based on the assumption of the source and position, any flares from this region may affect the Earth through 29 Jul.

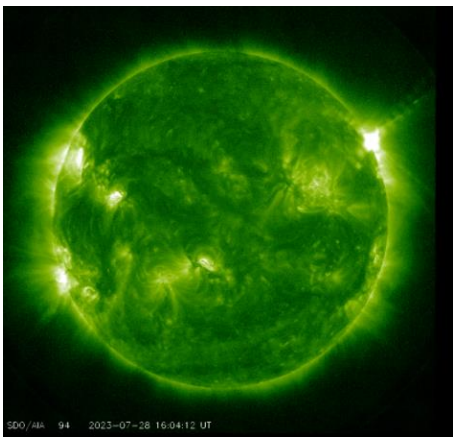
AR3380 has been the most developmental region on the visible disc, with a number of perimeter spots developing, which could be a sign of magnetic emergence and subsequent increasing complexity. This region may also have bene the location of a filament eruption early on 28 Jul, with a further eruption potentially in progress. AR3386 in the northeast is also increasingly complex. There are a number of region in the far east of the solar disc, which could reveal complex arrangements over the forecast period, despite currently appearing as benign regions.

Solar activity is expected to be mainly Low to Moderate, with a slight chance of X-class flares, mainly from AR3380 and AR3386, with a decreasing risk from ex-AR3376.

| X Ray Flares<br>Probability | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| Active | R1-R2 M Class | Yes | 60 | 50 | 50 | 50 |
| Very Active | R3 to R5 X Class | No | 5 | 5 | 5 | 5 |

**Figure 3: GOES 16 X-ray flux and SDO/AIA 94 imagery showing the M4.1 flare from ex-AR3376**





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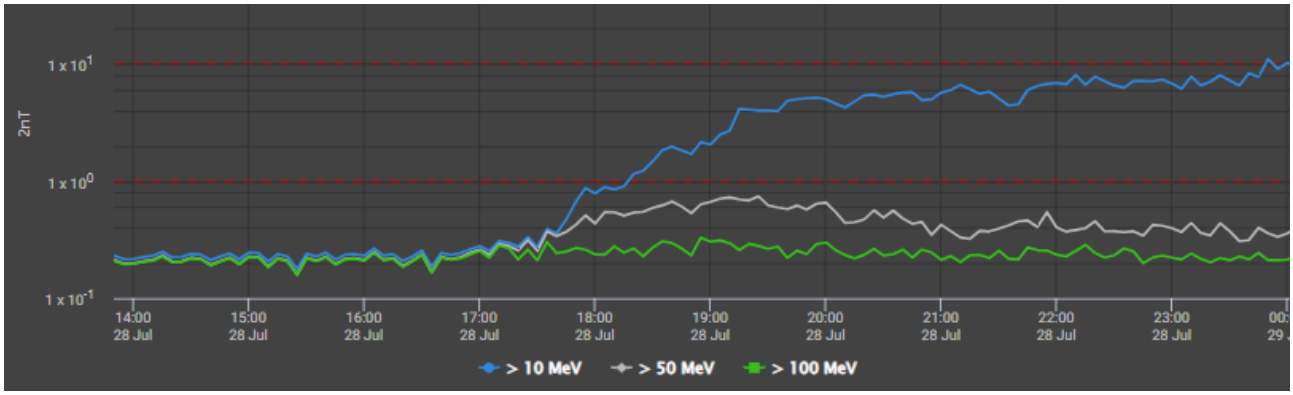
**Solar Radiation Storms - (High Energy Protons):**
The high energy (greater than 10MeV) proton flux observed by GOES16 is approaching the S1/Minor storm level due to a large farside eruption from the vicinity of ex-AR3376, associated with an M4.1 flare at 28/1558 UTC. The rate of increase has leveled off, but there remains a risk of a slower rise above the S1 threshold on 29 Jul, which could be enhanced by any further flares from this region. AR3380 is now becoming increasingly complex as it rotates into the western hemisphere, with an increasing risk of proton storms.

| Radiation Storms<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 30 | 10 | 10 | 10 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

**Figure 4: GOES 16 Proton Flux showing the proton flux close to the S1/Minor Storm threshold.**

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**High Energy Electrons Event (≥ 2MeV):**
High energy electron flux (greater than 2MeV) is expected to oscillate between background and moderate levels, with no significant inputs expected into the radiation belts through the next four days. The connection to coronal hole 28 may not have occurred, or only weakly occurred. If it did occur it only had limited impact on the solar wind and electron counts. The end of the forecast period is uncertain with a risk of geomagnetic enhancements from possible CMEs, which could notably affect the electron flux.

Electron fluence values are on a slowly rising trend and are not expected to exceed the Active (1e8 integrated pfu) threshold.

| GEO Electron Environment<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 10 | 10 | 10 | 10 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

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